Size distributions and the mass equivalence of chondrules and metal grains in Bjurbole: Karla E. Kuebler[1], Harry Y. McSween Jr.[1], and William D. Carlson[2], 1) Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996; 2) Dept. of Geological Sciences, University of Texas at Austin, Texas 78713

It is widely maintained that metal-silicate fractionation was an important process in the presolar nebula and was largely responsible for the observed chemical variations in the chondrite groups. This process is also purported to be the cause of the different size populations of chondrules from the different chondrite classes. Several studies have established the inverse relationship between chondrule size and chemical composition [1], [2], [3] and a similar size-frequency distribution has been argued for metal chondrules although they have a smaller average diameter, presumably the result of their higher density [4]. This led Scott and Haack [5] to propose that all chondrite components may have been sorted according to their masses prior to the accretion of the meteorite parent bodies. If this is the case, chondrule and metal grain populations should be mass equivalent despite their extreme differences in size and shape. To make this comparison, chondrules from four thin sections (total = 210) of Bjurbole were measured in reflected light and a four-gram sample of the same meteorite was imaged using x-ray tomography at 100 μm resolution so that the metal grains might be studied.

Chondrule measurements are subject to sampling biases due to thin sectioning [6], [7]. Because the evaluation of chondrule sorting depends upon the successful conversion of the apparent size distribution measured in thin section to the true size distribution, corrections must be made for these biases. The model of Eisenhour [6] was used to perform these corrections and the mean and median chondrule sizes were determined graphically from the results. It was then possible to calculate the volume of the average chondrule. All of these values are reported in Table 1. A norm calculation of the average chondrule composition reported by Grossman and Wasson [8] and the densities of the normative minerals was used to calculate the mass of the average chondrule. The mean and median chondrule diameters found for Bjurbole using the Eisenhour method were less than those found by Hughes [9] upon disaggregation. This discrepancy may be result of the destruction of smaller chondrules during disaggregation.

Because of the irregular sizes and shapes of metal and sulfide grains, a three dimensional method for analyzing the grains was necessary. Physicians use x-ray tomography (or X-RAY CT) to produce three-dimensional images of the brain (a CAT-SCAN). Researchers have modified the technique (intensified radiation, improved resolution) for other scientific endeavors. The images produced are based upon the variations in density at each of several thousand points in a two-dimensional "slice" of the object [10]. Contrast in the image arises from variations in the object's density, with darker regions corresponding to denser regions. These density changes are determined by passing a horizontal fan of x-rays through an object on a turntable. The intensities of the x-rays are measured before and after passing through the object, and are measured continuously as the object is rotated. This evaluates the attenuation of the x-rays by the object [10]. Because the object is rotated the x-rays pass through each point in the object several times, making it possible to calculate the attenuation of the beam at each point along its path. From this information an image of this horizontal plane, or "slice," is produced. By repeating the procedure and producing multiple slices one can create a continuous three-dimensional image [10]. This image is stored in a CD-ROM format from which hypothetical cross-sections can be made along two planes perpendicular to the original CT-slices. The images produced were analyzed using Adobe Photoshop where the metal and sulfide grains were outlined by selecting a threshold greyscale value. It was then possible to calculate the area of each grain in pixels and to convert this value to cm^2. After the area had been calculated for each grain in every slice the area of the grains was integrated over multiple slices to determine the volume. Using whole rock analyses of Bjurbole [11] the densities and proportions of Fe-Ni metal and troilite were used to determine the mass of the average grain present in Bjurbole. These values are also reported in Table 1.

These data are consistent with the nebular sorting of these components by mass. Analyses of other chondrites, now in progress, will further test this idea.

CHONDRULE AND GRAIN MASSES: Kuebler et al.

TABLE 1.

constituent	mean volume	density	mean mass
chondrules	0.131 mm^3	3.415 g/cm^3	0.00045 g
with rims	+ 0.202 mm^3		+ 0.00065 g
	- 0.097 mm^3		- 0.00033g
chondrules	0.119 mm^3	3.415 g/cm^3	0.00041 g
without rims	+ 0.226 mm^3		+ 0.00079 g
	- 0.097 mm^3		- 0.00033 g
metal and sulfide grains	0.021 mm^3	6.612g/cm^3	0.00013 g
	+ 0.068 mm^3		+ 0.00055 g
	- 0.020 mm^3		- 0.00001 g

References: [1] Hughes D.W. (1980) EPSL, 51, 26-28. [2] Rubin J., Scott E.R.D., Keil K. (1982) GCA, 46, 1763-1776 [3] Rubin J. (1989) Meteoritics, 24, 179-189. [4] Skinner W.R. and Leenhouts J.M. (1993) LLPSC XXIV, 1315. [5] Scott E.R.D. and Haack H. (1994) Meteoritics, 28, 434. [6] Eisenhour, D. D. (1996) Meteoritics, 31, 243-248. [7] Kuebler K. and McSween H.Y. (1996) LPSC XXVII, 715-716. [8] Grossman J. and Wasson J.T. (1983) in Chondrules and their origins, (King, E.A. ed.), 88-121. [9] Hughes D.W. (1978) EPSL, 38, 391-400. [10] Carlson W. D. and Denison C. (1992) Science, 257, 1236-1239. [11] Fredricksson K., Noonan A.F., and Nelen J. (1979) Lunar Science Abstracts X, 397-399.